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Estimating Sound Seeds in Ponderosa Pine Cones from Half-Face Counts

J. M. Schmid, S. A. Mata, and J. C. Mitchell[1]

Abstract

Cones from 10 areas in Arizona were dissected to determine the percentage of sound, hollow, and insect-damaged seed. The mean percentage of sound seed in the half-faces of 20 cones (two cones from each of 10 trees) from a stand estimated the same percentage for whole cones for that area within ± 10 units of the mean.

Keywords: seed crops, artificial regeneration, insect damage, *Pinus ponderosa*

Management Implications

Foresters can dissect two cones from each of 10 trees from a specific stand, count the sound and total seeds in one of the two half-faces of each cone, compute the percentage of sound seed, and thereby decide whether cones should be collected from that stand.

Introduction

Foresters frequently collect vast quantities of ponderosa pine, *Pinus ponderosa* Lawson, cones in September and October to supply a nursery with seed for seedling production or for direct seeding. During collection, the number of sound, hollow, or insect-damaged seeds in each cone cannot be determined by external observation. Conspicuously damaged cones like those infested by the ponderosa pine cone beetle, *Conophthorus ponderosae* Hopkins, are disregarded and not collected because the brown, incompletely developed cone is easily distinguished from green, mature cones. Because inconspicuous damage, such as that caused by the pine seed chalcid, *Megastigmus albifrons* Walker, cannot be observed without cone dissection (Schmid et al. 1984). *Megastigmus*-infested cones may be collected with sound cones. A high proportion of infested cones or infested seeds wthin each cone substantially increases the final cost of the sound seed or, in some instances, may mean the entire collection is worthless. Therefore, foresters need a simple, efficient method of determining the number or percentage of sound seeds in each cone.

In the past, cone crops have been evaluated by counting the number of sound seeds in the face of cones dissected lengthwise (USDA Forest Service 1974), commonly called the "half-face". A representative sample was collected from a stand, cones were cut lengthwise, and the sound seeds in one face of each cone were counted (Douglass 1969). When the average sound seed count was 8 or more per cone, the cone crop was suitable for collecting. This note reports on the modification of that procedure to evaluate cone crops in ponderosa pine stands in Arizona.

Methods

Ten cone production areas were selected in ponderosa pine stands, on the Coconino and Kaibab National Forests, in north-central Arizona. In each area, 10 trees were selected. Thirty conelets on each tree were tagged in July 1982 and were observed periodically during the next 2 years as part of a life table study. In

[1]*Entomologist and technicians, respectively, at the Rocky Mountain Forest and Range Experiment Station. Station headquarters is in Fort Collins, in cooperation with Colorado State University.*

August–September 1983, the cones were collected and refrigerated until dissection. Numbers of cones collected from each area are listed below.

Coconino National Forest	Number of cones
Cable	199
Deadman Flat	176
Hart Prairie	53
Highway 89	230
Rockledge	214
Schnebly Hill	140
Kaibab National Forest	
Devil Dog	173
Dutch Kid	66
Grandview	194
10X	99

After cone length was measured, each cone was dissected lengthwise to determine the number of sound, hollow, and insect-damaged seeds in the half-face. The face of that half which had the most cut seeds was selected for examination. The number of sound, hollow, and insect-damaged seeds by damaging species were recorded only for those seeds in the face which had the seed coat partially removed, thereby exposing the endosperm (fig. 1). Uncut whole seeds or seeds with abraded seed coats were not included on the half-face counts. Underdeveloped seeds at the top and base of the cone also were excluded. After the counts were made in the half-face, the entire cone was dissected to determine the total number of sound, hollow, and insect-damaged seeds in the cone.

Four linear regressions were then developed from the cone data: (1) total number of sound seeds; (2) the percentage of sound seeds in each cone were compared against the respective number and percentage of sound seeds in the half-face for each cone production area; (3) the mean percentage of sound seeds for all cones from an area was compared against the respective mean percentage of sound seeds in the half-face; and (4) number of sound seeds in a cone was compared against cone length.

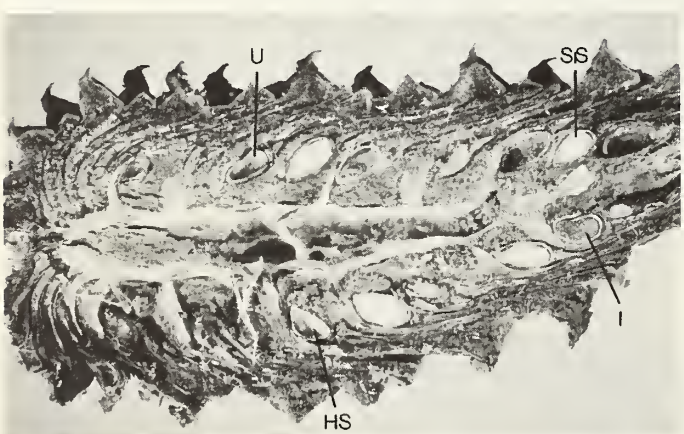

Figure 1.—Half-face of ponderosa pine cone depicting sound (SS), hollow seed (HS), insect-damaged (I), and uncut seeds (U).

After it was determined that the percentage of sound seeds in the half-face reflected the percentage of sound seeds in the whole cone, a sampling design was tested on the cone data to determine its accuracy and precision in estimating the mean percentage of sound seeds. Eight random samples of two cones per tree were selected from each of the 10 trees, from 7 of the locations where enough sound cones were available to provide a meaningful sample. The number of sound seeds and total seeds in the half-faces of the 20 cones were respectively added for each sample. Total sound seeds was divided by total seeds to determine the percentage of sound seeds in the half-face. The eight sample percentages from each area were compared to the mean percentage derived from all the cones from the same respective area. The accuracy and precision of the two-cone, 10-tree design for estimating the percentage of sound seeds for a given location were estimated using a chi-square procedure of Freese (1960).

Results and Discussion

Both the percentage and number of sound seed in the whole cone were linearly related to the respective percentage and number of sound seeds in the half-face; but, the linear regressions using percentage of sound seeds were consistently better. Because the mean number of sound seed in the half-face was less than seven for all areas, a difference of one or two seeds in the half-face creates a substantial difference in the percentage of sound seeds. This difference creates enough variability to make the number of sound seeds a poorer estimator than the percentage, and also makes it mandatory that only half-faces with the greatest number of exposed seeds be used in deriving the percentage.

Correlations of percentage of sound seed in the cone to percentage of sound seed in the half-face for individual cones ranged from poor to good with R^2 values of 0.16 to 0.71; 50% of the locations had R^2 values greater than 0.5. The lack of good correlations for the majority of the areas appears to be related to three factors. First, both the number of sound seeds per cone and mean sound seeds per cone per tree varied significantly. This variation influences the precision of the relationship between the whole cone and the half-face. Second, as mentioned previously, the mean number of sound seeds in the half-face was less than seven for all areas and exceeded 10 in less than 20% of the cones. Thus, a difference of one or two sound seeds in the half-face creates a difference in the percentage of sound seeds. Finally, significant variation was introduced by differences in worker accuracy.

Although the precision of correlations varied among areas, the correlation between the percentage of sound seed in the cone and the percentage in the half-face was very precise for the mean values for each area (fig. 2). The R^2 value was 0.92, which suggests that a definite relationship exists between sound seeds in the cone and sound seeds in the half-face, and that the percentage in the cone can be estimated from the same percentage in the half-face. However, because individual cone values

were so variable, a large sample of cones is needed to estimate the mean percentage.

The mean percentage as derived from two cones per tree, 10 trees per area samples was lower than the respective mean percentage of sound seed in whole cones for the 7 areas. The estimates were within ± 10 units of the "true" mean 100% (95% confidence) of the time in the eight simulated random samples for each area but were within ± 5 units of the mean only 60% of the time. For example, if the "true" mean for an area was 65%, the estimate was between 55% and 75% for every sample. Thus, the mean percentage of sound seed in the half-faces of two cones from each of 10 trees will estimate the mean percentage of sound seeds in the cones from a specific area. However, the "true" mean is based on 10 trees, which may not have captured the range of variation. If the 10 sample trees are not distributed throughout the stand, more than 10 trees may have to be sampled to capture this variation.

The operating procedure for making a decision to collect or not collect cones from a specific stand should be as follows: (1) Randomly collect two cones from each of at least 10 randomly selected trees distributed throughout the stand. Collect the cones from opposite sides of the tree and exclude aborted, *Conophthorus*-killed or otherwise damaged cones in the sample. Additional cones may be collected if desired; but, the additional samples will improve the accuracy of the estimate only when additional trees are sampled. Additional cones from each tree (for example, four cones per tree) will not improve the accuracy as much as adding additional trees, because the within-tree variation is small compared to the among tree variations. (2) Cut the cones in half lengthwise. (3) Determine the number of sound seed and total seed in the half-face having the larger number of seeds exposed by the dissection. A sound seed will have a solid white interior occupying all the area inside the seed coat; a hollow seed will be either completely hollow or will have a dried and shriveled seed remnant; an insect-damaged seed will be filled with frass or will have a larva present (fig. 1). (4) Compute the mean percentage of sound seeds for the 20 cones by dividing the sum of the sound seeds by the sum of the total seeds.

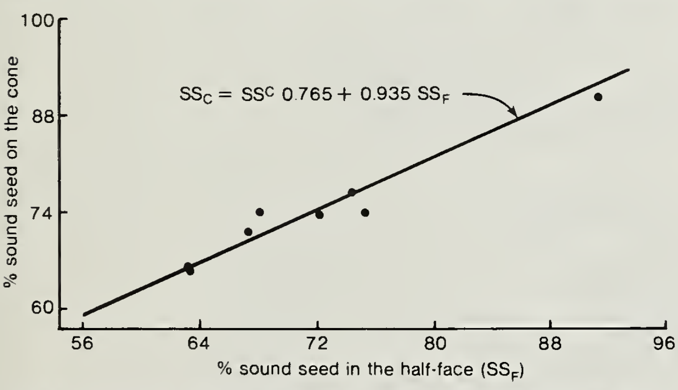

Figure 2.—Mean percentage of sound seeds in the cones (SS_C) from an area versus the respective mean percentage of sound seeds in the half-face (SS_F).

Decide what percentage of sound seed per cone must be available before cone collection begins. If seed is urgently needed from specific locations, collections may be made even though the mean percentage is low. Usually, however, the percentage of sound seed, the size of the cone crop, and the urgency of the need for seed will ultimately decide if cones are to be collected.

Although the percentage of sound seed can be used to make the collection decision, it is more desirable to know the yield of sound seed per bushel, because collections are funded and targeted on a bushel basis. In Arizona, a bushel of cones will yield from 1 to 1.5 pounds of seed. Multiplying 1.0 to 1.5 by the percentage of sound seed per cone will yield the pounds of sound seed per bushel. For example, if the percentage of sound seed is 75% and a bushel of cones yields 1 pound of seed, the sound seed yield would be 0.75 pound. Stated another way, an extra bushel of cones would have to be collected for every 3 bushels to obtain 3 pounds of sound seed.

If seed yields of 1 to 1.5 pounds per bushel for Arizona are composed entirely of sound seed, then deriving the sound seed yield per bushel by this above method will underestimate the yield. However, if hollow and insect-damaged seeds are present in the yield, then the method will more precisely estimate the pounds of sound seed.

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*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526